INDOOR AIR QUALITY ASSESSMENT

Center School
403 Great Road
Stow, MA 01775

Prepared by:
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Center for Environmental Health
Emergency Response/Indoor Air Quality Program
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Background/Introduction

At the request of a parent, the Massachusetts Department of Public Health's (MDPH) Centers for Environmental Health (CEH) conducted an indoor air quality assessment at the Center School (CS), 403 Great Road, Stow, Massachusetts. On April 7, 2005, a visit to conduct an indoor air quality assessment was made to the CS by Sharon Lee, an Environmental Analyst in CEH's Emergency Response/Indoor Air Quality (ER/IAQ) Program. The request was prompted by concerns of poor indoor air quality and mold.

The CS is a single-story building constructed in 1954. Additions were made to the building in 1956 and 1964. The school consists of classrooms, a gymnasium, a computer room, a library and offices. Windows throughout the school are openable. In addition, a stone shed previously used for apple storage is located behind the CS. The shed, known as the Stone Building, has been renovated and is currently used for science classes.

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were conducted with the TSI, Q-Trak, IAQ Monitor, Model 8551. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID). MDPH staff performed a visual inspection of building materials for water damage and/or microbial growth.

Results

The school houses approximately 265 students in third through fifth grades and approximately 35 staff members. Tests were taken during normal operations at the school and results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were above 800 parts per million (ppm) in 15 of 28 areas surveyed, indicating poor ventilation and air exchange in approximately half of the areas surveyed. It is important to note that several areas were empty or sparsely populated and/or had windows and exterior doors open at the time of assessment. Low occupancy and open windows/exterior doors can greatly reduce carbon dioxide levels. Carbon dioxide levels would be expected to be higher with increased occupancy and with windows/exterior doors shut.

Fresh air in classrooms is supplied by unit ventilator (univent) systems (Picture 1). A univent is designed to draw air from outdoors through a fresh air intake located on the exterior wall of the building (Picture 2) and return air through an air intake located at the base of the unit (Figure 1). Fresh and return air are mixed, filtered, heated and provided to classrooms through an air diffuser located in the top of the unit. Many univents were operating weakly or found to be off at the time of assessment. Obstructions to airflow, such as papers and books stored on univents and bookcases and carts and desks located in front of univent returns, were seen in a few classrooms (Picture 3). In order for univents to provide fresh air as designed, units must be allowed to operate and remain free of obstructions. Please note, univents appear to be original to the building. Therefore, repair/ replacement of parts may be difficult for units of this age.

The univent located in the Stone Building is controlled by a thermostat with switch activated 'day' and 'night' settings (Picture 4). At the time of the assessment, the univent was in the night setting. The night setting on the thermostat activates the HVAC system at a preset temperature, approximately 60 ^{o} F. Once the preset temperature is reached, the HVAC system is deactivated. Therefore, no mechanical ventilation is provided until the thermostat re-activates the system. The school custodian switched the univent to the day setting, essentially activating the univent. According to the school custodian, during routine univent filter changes, the filter for the Stone Building univent is not typically soiled in comparison to other CS classroom univents. This suggests that the univent is rarely switched from the night to day mode. Without operating the unit, no means for supplying fresh air to the Stone Building exists. As a result, typical classroom pollutants would tend to accumulate, leading to occupant discomfort and complaints regarding indoor air quality.

Exhaust ventilation in classrooms is provided by ducted, grated wall vents powered by rooftop motors. At the time of the assessment some exhaust vents were not operating. In addition, a number of wall exhaust vents were obstructed by desks, bookcases and other items (Picture 5). As with the univents, in order to function properly, exhaust vents must be activated and remain free of obstructions.

Many offices and rooms used for small group activities (e.g., speech, guidance) did not have mechanical supply or exhaust. These rooms rely solely on windows for fresh air supply. Opening windows during the heating season in New England is not practical.

Consideration should be given to undercutting doors to these classrooms to provide air exchange.

Like many offices/rooms, the guidance office relies on windows for fresh air. However, this room also has a fan coil unit (FCU) that provides supplemental heating to the room (Picture 6). The FCU functions in a manner similar to that of a univent, where air drawn into the FCU is filtered, mixed with return air and distributed to the room. Unlike a univent, however, this heating unit has both intake and exhaust vents on a wall shared with the hallway (Pictures 7 and 8). This unit was not operating at the time of assessment. Consideration should be given to deactivating heating elements to allow a source of air to circulate in this room during the non-heating season.

To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room, while removing stale air from the room. It is recommended that HVAC systems be re-balanced every five years (SMACNA, 1994). The date of the last balancing was not available at the time of the assessment.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The MDPH uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please consult Appendix A.

Temperature measurements ranged from 68° F to 76° F, which were within or slightly below the MDPH recommended comfort guidelines in some areas. The MDPH recommends that indoor air temperatures be maintained in a range of 70 ° F to 78 ° F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. In addition, temperature control is often difficult without operating the ventilation systems as designed (e.g., univents/exhaust vents deactivated/obstructed).

The relative humidity measurements in the building ranged from 33 to 41 percent, which were slightly below or at the lower end of the MDPH recommended comfort range. The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

A few areas had water-damaged ceiling tiles (Picture 9), which can indicate leaks from the roof or plumbing system. Water-damaged ceiling tiles can provide a source for mold growth and should be replaced after a water leak is discovered and repaired. Tiles glued directly to the ceiling system are more difficult to remove. For that reason appropriate precautions should be taken when removing and replacing these tiles.

The US Environmental Protection Agency (US EPA) and the American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). If porous materials are not dried within this time frame, mold growth may occur. Water-damaged porous materials cannot be adequately cleaned to remove mold growth. The application of a mildewcide to moldy porous materials is not recommended.

Plants were observed in several classrooms. In some areas, plants were observed on carpeting (Picture 10). Plants, soil and drip pans can serve as sources of mold growth, thus should be properly maintained. Over-watering of plants should be avoided and drip pans should be inspected periodically for mold growth. Plants and related materials should also be located away porous materials (e.g. carpeting, paper products) to prevent damage and potential microbial growth in/on these materials.

A number of aquariums and terrariums were seen in classrooms (Pictures 11 and 12). Aquariums should be properly maintained to prevent microbial/algae growth, which can emit unpleasant odors. Similarly, terrariums should be properly maintained to ensure soil does not become a source for mold growth.

Plants were observed to be growing against the foundation walls (Picture 13). The growth of roots against exterior walls can bring moisture in contact with the foundation. Plant roots can eventually penetrate, leading to cracks and/or fissures in the sublevel foundation. The gutter/downspout system was damaged/missing in several areas or improperly connected to drainage pipes (Pictures 14 and 15). Excessive exposure of the exterior brickwork and foundation to water can result in structural damage. Over time, these conditions can undermine the integrity of the building envelope and provide a means of water entry into the building through capillary action through foundation concrete and masonry (Lstiburek & Brennan, 2001). In addition, a portion of the damaged downspout appears to be serving as a nesting site for birds.

During the assessment, MDPH staff observed birds flying in and out of the attic crawlspace via a louver (Picture 16), indicating the potential for birds to be roosting in the attic crawlspace. Measures should be taken to prevent bird entry into the building.

Consideration should be given to installing bird screens/netting to prevent access. Birds can be a source of disease, and bird wastes and feathers can contain mold, which can be irritating to the respiratory system. Certain molds are associated with bird waste and are of concern for immune-compromised individuals. Other diseases of the respiratory tract may also result from chronic exposure to bird waste. Exposure to bird wastes is thought to be associated with the development of hypersensitivity pneumonitis in some individuals. Psittacosis (bird fancier's disease) is another condition closely associated with exposure to bird wastes in either the occupational or bird rearing setting. While immune-compromised individuals have an increased risk of health impacts following exposure to the materials in bird wastes, these impacts may also occur in healthy individuals exposed to these materials.

The methods employed for cleaning of a bird waste problem depend on the amount of waste and the types of materials contaminated. The MDPH has been involved in several indoor air investigations where bird waste has accumulated within ventilation ductwork (MDPH, 1999). Accumulation of bird wastes have required the clean up of such buildings by a professional cleaning contractor. In less severe cases, the cleaning of the contaminated material with a solution of sodium hypochlorite has been an effective disinfectant (CDC, 1998). Disinfection of non-porous materials can be readily accomplished with this material. Porous materials contaminated with bird waste should be examined by a professional restoration contractor to determine whether the material is salvageable. Where a porous material has been colonized with mold, it is recommended that the material be discarded (ACGIH, 1989). Guidance regarding bird waste clean up is included as Appendix B.

Other IAQ Evaluations

Indoor air quality can be negatively influenced by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion emissions include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, MDPH staff obtained measurements for carbon monoxide and PM2.5.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address carbon monoxide and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

The American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE) has adopted the National Ambient Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from six criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2000a). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS levels (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000a).

Carbon monoxide should not be present in a typical, indoor environment. If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels. On the day of assessment, outdoor carbon monoxide concentrations were non-detect (ND) (Table 1). Carbon monoxide levels measured in the school were also ND (Table 1).

The US EPA has established NAAQS limits for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. The NAAQS originally established exposure limits to particulate matter with a diameter of 10 μm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 microgram per cubic meter ($\mu g/m^3$) in a 24-hour average (US EPA, 2000a). These standards were adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA proposed a more protective standard for fine airborne particles. This more stringent PM2.5 standard requires outdoor air particle levels be maintained below 65 $\mu g/m^3$ over a 24-hour average (US EPA, 2000a). Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, MDPH uses the more protective proposed PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations were measured at 27 μg/m^3 (Table 1). PM2.5 levels measured were between 19 to 57 μg/m^3 in the main CS building which were above outdoor measurement in some areas, but below the NAAQS of 65 μg/m^3 (Table 1). Frequently, indoor air levels of particulates can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can generate particulates during normal operation. Sources of indoor airborne particulate may include but are not limited to particles generated during the operation of fan belts in the HVAC system, cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices, operating an ordinary vacuum cleaner and heavy foot traffic indoors.

The PM2.5 level measured in the Stone Building was 213 μg/m^3, which was above outdoor and NAAQS levels. The PM2.5 levels measured in this building reflect the dust load within the classroom. As discussed, the Stone Building is a renovated apple storage barn that is separate from the main CS building. Students must enter the building after walking though an unpaved sandy road, tracking dust into the building. Windows in the building were closed, and the univent was not operating at the time of assessment. A number of surfaces throughout the Stone Building, especially window ledges, were found with accumulated dust. In addition, portions of the floor consist of unfinished cement, which makes dust control difficult. Consideration should be given to providing a rubberized bristle-top floor mat to allow students to remove debris from shoes. Further, as mentioned previously the univent should be operating in the "day" setting. Flat surfaces should be wet wiped and cleaned with a vacuum equipped with the high efficiency particulate arrestance (HEPA) filter on a regular basis.

Indoor air quality can also be negatively influenced by the presence of materials containing volatile organic compounds (VOCs). VOCs are carbon-containing substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. An outdoor air sample was taken for comparison. Outdoor TVOC concentrations were ND (Table 1). Indoor TVOC concentrations were ND (Table 1).

Please note, TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use of TVOC containing products. In an effort to identify materials that can potentially increase indoor TVOC concentrations, MDPH staff examined classrooms for products containing these respiratory irritants. Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat.

Cleaning products were found on countertops and in unlocked cabinets beneath sinks in some classrooms (Picture 17). Like dry erase materials, cleaning products contain VOCs and other chemicals that can be irritating to the eyes, nose and throat of sensitive individuals. Use of air deodorizers aerosolizes VOCs; thus, instead of removing the materials causing odors, the odors are masked.

Several other conditions that can affect indoor air quality were noted during the assessment. Of note was the amount of materials stored inside classrooms. In classrooms throughout the school, items were seen on windowsills, tabletops, counters, bookcases and desks. The amount of items stored provides a means for dusts, dirt and other potential respiratory irritants to accumulate. Many of the items (e.g., papers, folders, boxes) make it difficult for custodial staff to clean.

Supply and return vents for univents, exhaust vents and fan blades to personal fans were also occluded with dust (Pictures 18 and 19). Reactivated fans and univents can serve to distribute accumulated dust. If exhaust vents become deactivated, backdrafting can result in the re-aerosolization of accumulated dust particles. Dust can also be irritating to the eyes, nose and respiratory tract. Accumulated chalk dust was noted in some classrooms. Chalk dust is a fine particulate that can easily become aerosolized, irritating eyes and the respiratory system. As discussed, flat surfaces should be wet wiped and cleaned with a vacuum equipped with the high efficiency particulate arrestance (HEPA) filter on a regular basis.

A number of classrooms contained upholstered furniture and pillows. Upholstered furniture is covered with fabric that encounters human skin. This type of contact can leave oils, perspiration, hair and skin cells. Dust mites feed upon human skin cells and excrete waste products that contain allergens. In addition, if relative humidity levels increase above 60 percent (e.g., during spring/summer), dust mites tend to proliferate (US EPA, 1992). In order to remove dust mites and other pollutants, frequent vacuuming of upholstered furniture is recommended (Berry, 1994). It is also recommended that if upholstered furniture is present in schools, it should be professionally cleaned on an annual basis or every six months if dusty conditions exist outdoors (IICR, 2000).

A number of insect nests were observed on roof eaves/exterior wall areas around the perimeter of the building (Picture 20). These nests should be removed in a manner as to not introduce pesticides and/or insects into the building. Under current Massachusetts law that, effective November 1, 2001, the principles of integrated pest management (IPM) must be used to remove pests in state buildings and grounds (Mass Act, 2000).

Lastly, re-use of food containers and improperly stored food items were observed. Proper food storage is an integral component in maintaining indoor air quality. Food should be properly stored and clearly labeled. Reuse of food containers is not recommended since food residue adhering to the surface may serve to attract pests.

Recommendations

In view of the findings at the time of the visit, the following recommendations are made:

1. Operate both supply and exhaust ventilation continuously, independent of classroom thermostat control, during periods of school occupancy to maximize air exchange.
2. Examine each univent for function to ascertain if an adequate air supply exists for each room. Check fresh air intakes for repair and increase the percentage of fresh air intake if necessary.
3. Remove all blockages from univents and exhaust vents to ensure adequate airflow. Clean univent and exhaust vents periodically to prevent excessive dust build-up.

4. Use openable windows/exterior doors in conjunction with classroom univents and exhaust vents to increase air exchange. Care should be taken to ensure windows and doors are properly closed at night and weekends to avoid the freezing of pipes and potential flooding.
5. Consult a ventilation engineer concerning balancing of the ventilation systems. Ventilation industrial standards recommend that mechanical ventilation systems be balanced every five years (SMACNA, 1994).
6. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
7. Prompt attention should be given to the Science building given the relatively high PM 2.5 level. The recommendations mentioned on page 12 should be addressed as soon as possible.
8. Ensure all roof and/or plumbing leaks are repaired.
9. Replace water-stained ceiling tiles. Examine the areas above and around these tiles for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial. Consider removal of glued ceiling tiles as a renovations activity. Removal of tiles directly adhered to the ceiling would be considered a renovation activity, since tile removal can release particulates and spores in particular, if the material is moldy.

Replacement of ceiling tiles may involve glues that contain VOCs. In order to minimize occupant exposure, repairs should be done while the building is unoccupied.

10. Examine all gutters and downspouts to ensure all components are intact and attached in an appropriate manner. Replace all damaged gutters and downspouts to prevent water infiltration.
11. Consider installing bird screens to prevent bird roosting in the attic crawlspace.
12. Ensure plants are located away from air streams.
13. Refrain from placing plants on porous materials (i.e. carpeting).
14. Remove plants from the foundation wall junction around the perimeter of the building. Seal the junction with an appropriate sealer.
15. Clean and maintain aquariums and terrariums to prevent mold growth and associated odors.
16. Consider placing a rubberized bristle-top floor mat at the entrance of the Stone Building.
17. Ensure flat surfaces (e.g., window ledges and floors) are wet wiped and cleaned with a vacuum equipped with a HEPA filter on a regular basis.
18. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
19. Clean accumulated dust from exhaust vents and blades of personal fans.
20. Clean chalkboard/dry erase marker trays and pencil sharpeners regularly to prevent the build-up of excessive chalk dust and particulates.

21. Store cleaning products properly and out of reach of students.
22. Clean upholstered furniture on the schedule recommended in this report. If not possible/practical, remove upholstered furniture from classrooms.
23. Remove nests in a manner consist with the principles of IPM (Mass Act, 2000). An IPM implementation booklet is available from the Department of Agriculture: http://www.mass.gov/agr/pesticides/publications/IPM_kit_for_bldg_mgrs.pdf.
24. Refrain from re-using food containers, and ensure food products are stored in appropriate labeled containers.
25. Consider adopting the US EPA (2000b) document, *Tools for Schools*, in order to provide self-assessment and maintain a good indoor air quality environment. This document is available at: http://www.epa.gov/iaq/schools/index.html.
26. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. Copies of these materials are located on the MDPH's website: http://mass.gov/dph/indoor_air

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Picture 1

Classroom univent

Picture 2

Univent fresh air intake

Picture 3

Obstructions to a univent

Picture 4

Thermostat controls to Stone Building univent

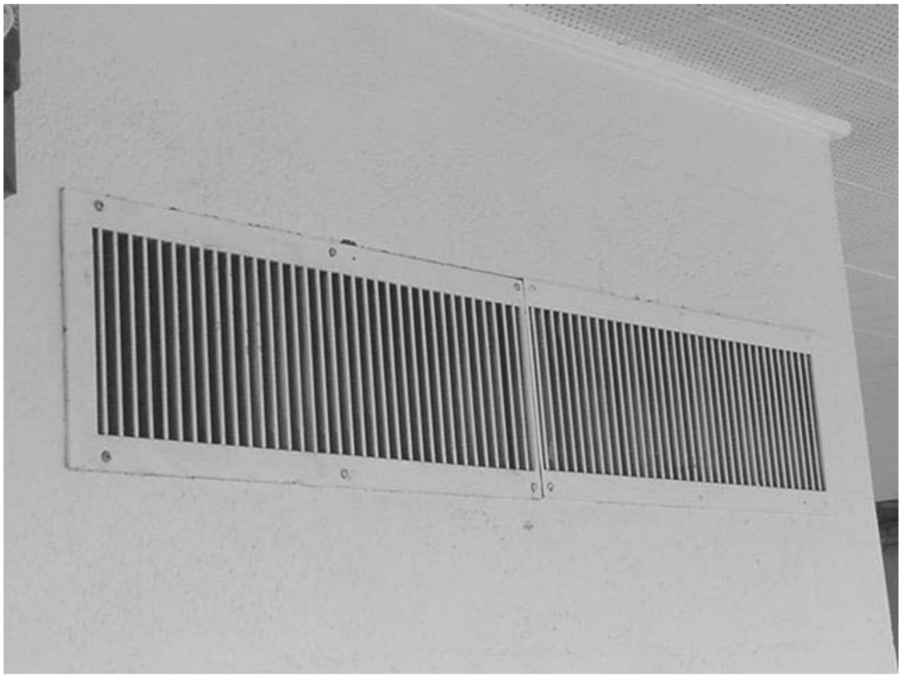
Picture 5

Classroom exhaust, note obstruction by table

Picture 6

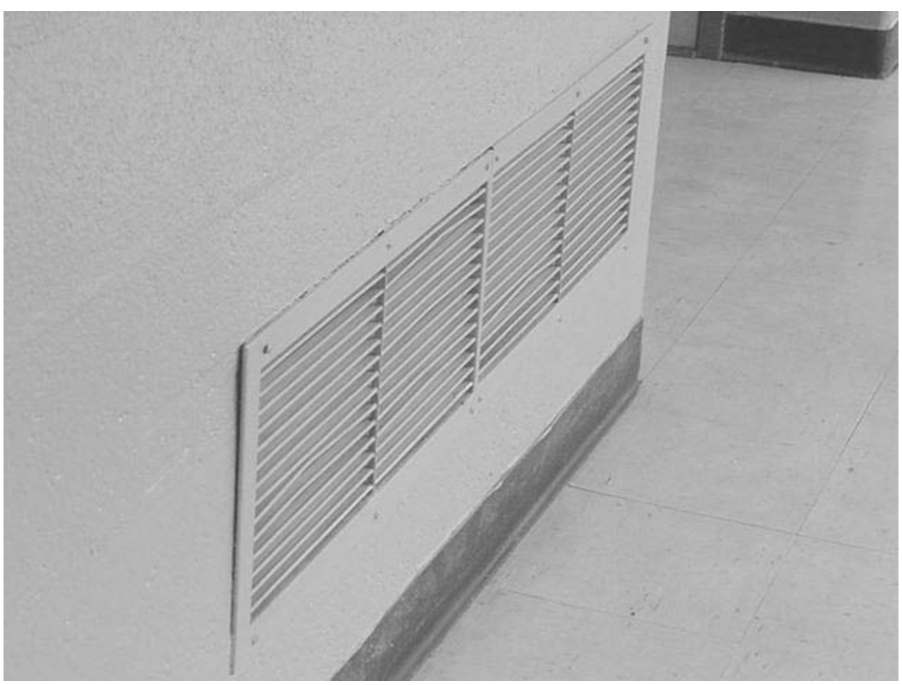
Classroom fan coil unit

Picture 7



Fan coil unit intake in hallway

Picture 8



Fan coil unit exhaust in hallway

Picture 9

Water damage to glued ceiling tiles

Picture 10

Plant on carpet

Picture 11

Aquarium

Picture 12

Terrarium

Picture 13

Plants growing against building foundation

Picture 14

Damaged downspout

Picture 15

Downspout detached from drainage pipe

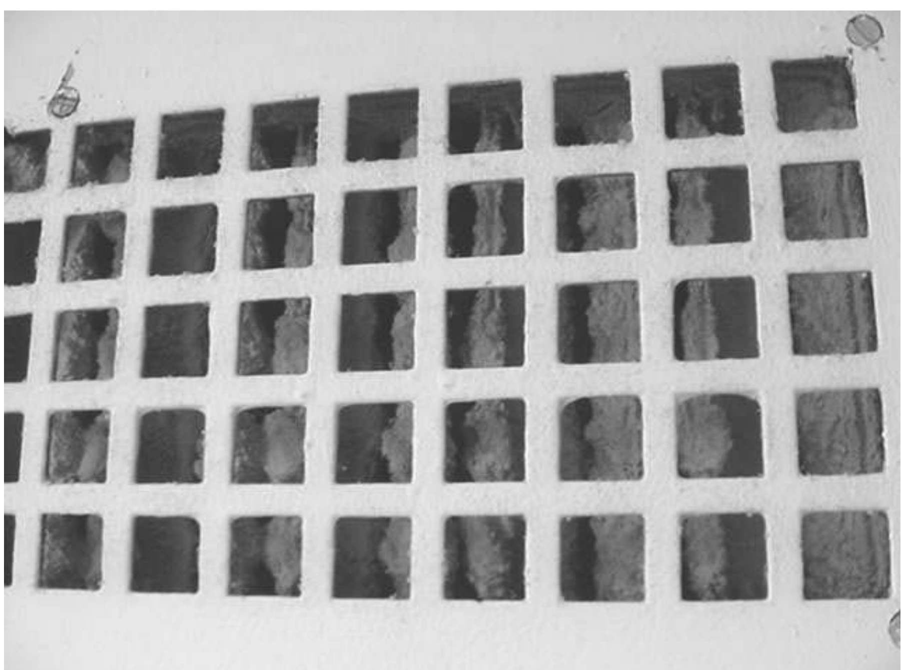
Picture 16

Passive louver to attic crawlspace

Picture 17

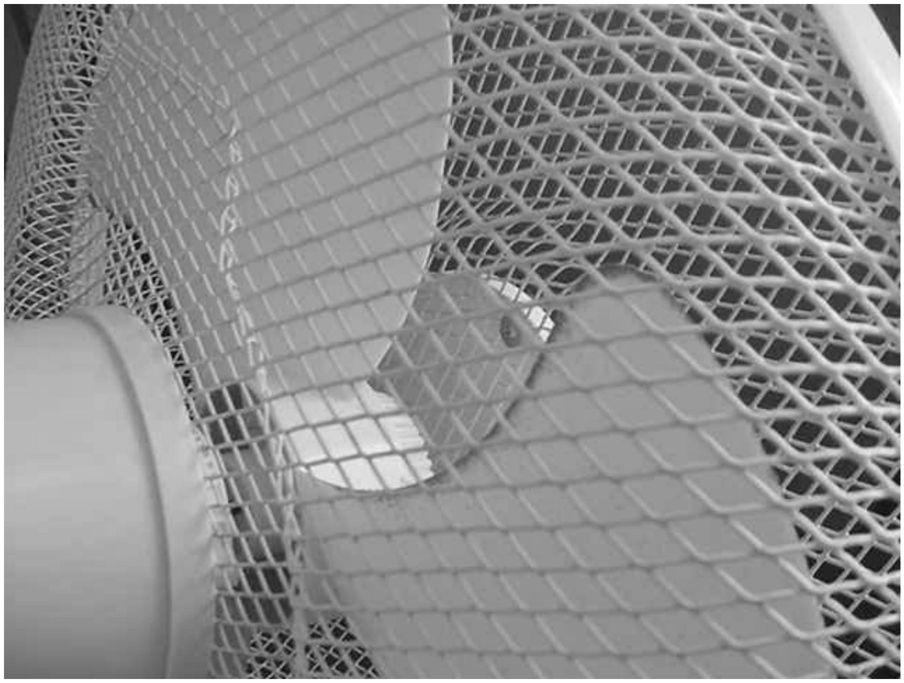
Cleaners in unlocked sink cabinet

Picture 18



Dust occluded exhaust

Picture 19



Dust occluded fan blades

Picture 20

Insect nests

Center School

403 Great Road, Stow, MA 01775

Indoor Air Results

April 7, 2005

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
background	0	52	41	389	ND	ND	27	N # open: 0 # total: 0			
art	0	69	34	717	ND	ND	19	Y # open: 0 # total: 6	Y univent (off)	Y wall	DEM, FC re-use.
guidance	3	71	38	1028	ND	ND	35	Y # open: 0 # total: 2	N	N	Hallway DO, items.
gymnasium/ cafeteria	90	73	36	562	ND	ND	28	N # open: 0 # total: 0	Y ceiling	Y wall (off)	#WD-CT: 21.
kiln room								N # open: 0 # total: 0			kiln will be vented through chimney.

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile

NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings

sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
WD = water damage
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Center School **Indoor Air Results**

403 Great Road, Stow, MA 01775 **April 7, 2005**

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
main office	1	71	36	768	ND	ND	21	N # open: 0 # total: 0	N	N	Hallway DO, DEM, cleaners, pets.
meeting room	0	70	36	563	ND	ND	29	N # open: 0 # total: 0	N	N	
music	6	72	36	1325	ND	ND	24	Y # open: 0 # total: 6	Y univent	Y wall	CD, DEM.
Principal's office	0	71	36	1011	ND	ND	22	N # open: 0 # total: 2	N	N	Hallway DO, Inter-room DO,
remedial reading room	0	70	35	835	ND	ND	35	Y # open: 0 # total: 6	N	N	Exterior DO, DEM, space heater.

ppm = parts per million
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AP = air purifier
aqua. = aquarium

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CD = chalk dust
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design = proximity to door
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sci. chem. = science chemicals
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Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

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									Supply	Exhaust	
speech room	1	71	34	776	ND	ND	20	Y # open: 0 # total: 1	N	N	
stone building (science room)	1	68	35	961	ND	ND	213	N # open: 0 # total: 0	Y univent (off)	N	dust, univent was on "night" setting, but was activated to "day" setting.
1a (resource room)	2	70	37	777	ND	ND	27	Y # open: 0 # total: 6	Y univent items furniture	Y wall items	Hallway DO, DEM.
1b (small resource room)	0	70	36	801	ND	ND	24	N # open: 0 # total: 0	N	N	Inter-room DO, CD, DEM.
2	25	73	34	1535	ND	ND	25	N # open: 0 # total: 0	Y univent (off)	Y wall	window-mounted AC, DEM, aqua/terra, cleaners.

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3	22	72	41	2094	ND	ND	57	Y # open: 0 # total: 6	Y univent (off)	Y wall	DEM, PF, UF, cleaners, items, plants.
4	25	72	38	767	ND	ND	32	Y # open: 0 # total: 6	Y univent (off) items	Y wall (off)	Exterior DO, #MT/AT: 2, DEM, cleaners, items, FC re-use.
5	23	73	37	2828	ND	ND	34	Y # open: 0 # total: 6	Y univent (off)	Y wall	#WD-CT: 24, DEM, cleaners, items.
6	15	73	38	1431	ND	ND	28	Y # open: 0 # total: 6	Y univent (off) plant(s)	Y wall boxes items furniture	#MT/AT: 1, DEM, cleaners.

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									Supply	Exhaust	
7	24	72	38	1420	ND	ND	41	Y # open: 0 # total: 6	Y univent (off) items	Y wall (off)	DEM, cleaners, items.
8	8	73	33	981	ND	ND	21	Y # open: 0 # total: 6	Y univent (off)	Y wall (off)	#MT/AT: 1, DEM, aqua/terra, cleaners, FC re-use, food use/storage, plants.
9	0	70	38	744	ND	ND	32	Y # open: 0 # total: 6	Y univent (off)	Y wall	Hallway DO, window-mounted AC, DEM, items, plants.
10	23	73	36	1178	ND	ND	26	Y # open: 0 # total: 6	Y univent furniture	Y wall	Hallway DO, DEM, UF, cleaners, items.

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									Supply	Exhaust	
11	24	69	40	631	ND	ND	28	Y # open: 1 # total: 6	Y univent items furniture	Y wall	Hallway DO, #WD-CT: 34, DEM, cleaners, plants.
12	21	72	37	736	ND	ND	33	Y # open: 0 # total: 6	Y univent	Y wall	Exterior DO, DEM, cleaners, items, food use/storage.
13 (library)	1	76	33	753	ND	ND	22	Y # open: 0 # total: 6	Y univent (off)	Y wall	Hallway DO, window-mounted AC, #MT/AT: 1, cleaners.
15 (computer lab)	25	72	37	810	ND	ND	25	Y # open: 1 # total: 6	Y univent (off)	Y wall	window-mounted AC, DEM, 40 computers.

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									Supply	Exhaust	
17	0	68	41	446	ND	ND	31	N # open: 0 # total: 0	Y univent (off) items	Y wall	Exterior DO, DEM, plants, exhaust louvers closed.
18	1	69	36	1056	ND	ND	27	Y # open: 0 # total: 6	Y wall furniture	Y wall furniture	Hallway DO, DEM, cleaners.

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